## **ATTACHMENT A**

# Canyon Ferry Lake Numeric Nutrient Criteria Development using a Computer Water Quality Model

Sampling Plan in Cooperation with the U.S. Geological Survey and the Environmental Protection Agency

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## **TABLE OF CONTENTS**

TABLE OF CONTENTS	ii
1.0 Introduction and Background Information	3
2.0 Objectives and Design of the Investigation	3
2.1 Primary Question and Objectives	3
3.0 Field Sampling Methods	3
3.1 Sites and Sampling Frequency	3
3.2 Lake Sampling	5
3.2.1 Secchi Depth and Determining Lake Stratification via Vertical Profile	5
3.2.2 Sample Collection within each Identified Lake Water Layer	6
3.2.4 Protocol for Deriving Sonde Depth when Boat Drift is Substantial and Sonde is Not Ewith a Depth Sensor	
3.2.5 Lake-bottom Sediment Oxygen Demand (SOD)	13
3.3 River Inflow and Outflow Sampling	15
3.4 Instruments (Lake and Riverine Sites)	17
3.5 Shoreline/beach Areas: Cyanotoxin and Taste & Odor Sampling	17
3.6 Physical and Habitat Parameters	18
3.6.1 Digital Photographs	18
3.6.2 Meteorological Measurements	18
4.0 Sample Handling Procedures	18
5.0 Laboratory Analytical Methods	18
6.0 Quality Assurance and Quality Control Requirements	18
6.1 YSI 6600 V2-4 Calibration	19
7.0 Data Analysis, Record Keeping, and Reporting Requirements	19
8.0 Schedule	20
9.0 Project Team and Responsibilities	20
10.0 Deferences	20

### 1.0 Introduction and Background Information

This sampling plan (SP) is intended to provide details on field and laboratory methods to be undertaken in support of the Canyon Ferry Lake QAPP. The project's QAPP provides the rationale for the overall project and, specifically, use of the CE-QUAL-W2 computer model. The project's objective is to derive numeric nutrient criteria for the reservoir. This SP details the methods, sampling sites, and schedule for work to be completed in 2015 and 2016 on Canyon Ferry Lake and its principal inlet and outlet. Work is being carried out by both MT DEQ and the U.S. Geological Survey (USGS) via a cooperative joint funding agreement, and the Environmental Protection Agency (EPA).

## 2.0 OBJECTIVES AND DESIGN OF THE INVESTIGATION

## 2.1 PRIMARY QUESTION AND OBJECTIVES

Please refer to the QAPP under Section 3.0.

## 3.0 FIELD SAMPLING METHODS

## 3.1 SITES AND SAMPLING FREQUENCY

Sampling events are planned to be monthly beginning in April 2015 and ending in November 2015, and then resuming the following year. **Table 3-1** summarizes proposed locations and frequency for 2015 and 2016. Changes to these sites and frequencies may occur due to unforeseen problems.

Table 3-1. Sampling schedule for Canyon Ferry Lake and Missouri River sites 2015 through 2016.

				201	5		2016										
Sites	A	M	J	J	A	S	0	N	D through M	Α	M	J	J	Α	S	0	N
Canyon Ferry Lake sites (3 sites, each site will be sampled at 3 depths)	-	1	1	1	1	1	1	1	-	1	1	1	1	1	1	1	1
Missouri River at the Hwy 287 bridge at Townsend	1*	2	2	2	2	1	1	1	-	1	2	2	2	2	2	1	1
Missouri River below Canyon Ferry Dam	1*	2	2	2	2	1	1	1	-	1	2	2	2	2	2	1	1
Shoreline sites (5)	-	1	1	1	1	1	1	1	-	1	1	1	1	1	1	1	1

<sup>\*</sup> This month only under JFA placed in 2014

Figure 3-1 shows the locations of the three sampling sites in Canyon Ferry Lake and the five shoreline

sites. The three sites in the lake align with sites sampled by Priscu (1987) and Horn and Boehmke (1998). Station 1 is well outside of the safely-limit buoy line which is stretched across the lake near the dam.

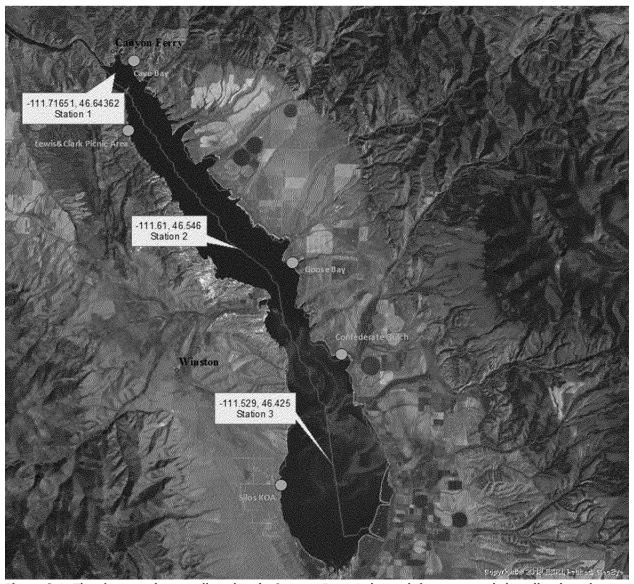


Figure 3-1. The three main sampling sites in Canyon Ferry Lake and the proposed shoreline locations.

The riverine sites (-inflow,outflow, not included in **Figure 3-1**) are at established USGS gage stations on the Missouri River:

- Inflow: Missouri River at the Hwy 287 bridge at Townsend MT (06057000)
- Outflow: Missouri River below Canyon Ferry dam (06058502)

## 3.2 LAKE SAMPLING

Three sampling sites in the lake (**Figure 3-1**) will be reached by boat equipped with an outboard motor. The boat may be anchored at site. If it is not feasible to anchor, use GIS-based boat stabilizing equipment or deploy a sea-anchor to minimize drift during the sampling event.

**NOTE:** If anchoring on-site is impossible and wind causes substantial lateral drift, the YSI cable may form a steep angle relative to the boat. If this angle becomes significant (as judged by the field crew) <u>and you are working with a sonde without a calibrated depth sensor or if the depth sensor fails, see protocol in **Section 3.2.4**.</u>

## 3.2.1 Secchi Depth and Determining Lake Stratification via Vertical Profile

### Use MT DEQ Stratification & Secchi Form. Mark all units where prompted!

A standard 20 or 30-cm diameter Secchi Disc will be used to take secchi depth on the shaded side of the boat (**remove your sunglasses!**) between 9 am and 3 pm (10 am to 2 pm is best). Record the 'disappear' and 'reappear' depths, and calculate the average (Lind, 1979).

**Vertical Profile:** (See **Section 6.1** for YSI calibration details). A YSI 6600 V2-4 sonde with cable and depth measurement capability (transducer) will be used to measure dissolved oxygen (DO), temperature (T°C), pH, conductivity (SC), turbidity, chlorophyll a, and phycocyanins in a vertical profile <u>every meter</u>, starting 0.5 m below the surface to the bottom. The depth transducer of the instrument is to be calibrated on site as follows:

- 1. Assure that the depth transducer's water passage tube is clear of fouling (use plastic syringe and some lake water to clear).
- 2. Zero the depth sensor just above the water's surface and record the barometric pressure.
- 3. Lower the instrument.
- 4. Check to assure that the sonde's transducer data align with the marked cable depths.

Record all YSI parameters in **Table 3-2¹** at each depth by logging the data into the hand-held YSI 650 (per YSI's manual) after sonde readings are reasonably stable (best professional judgement after training). Hand-record only DO and temperature on the 'Stratification & Secchi Form' and record the logging file name there too. Also on the form, record Li-COR light measurements at the corresponding depths.

Determine the extent of the epilimnion, thermocline, and hypolimnion (Figure 3-2). The epilimnion is defined as the surface to the onset of the thermocline. The thermocline, i.e. metalimnion, is the depth range in the lake where the rate of temperature change is greatest in the vertical profile. This equates to at least a  $1\,^{\circ}$ C drop with each  $1\,$ m depth increase (Cole, 1983). Where the drop in water temperature then diminishes to <  $1\,^{\circ}$ C per meter of depth, the thermocline has terminated. The hypolimnion is the layer from the termination of the thermocline to the lake bottom. Review your hand-recorded DO and temperature data on the 'Stratification & Secchi Form' to aide in determining the break points. It is possible that the lake may not be discernably stratified if sampled early in the year.

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<sup>&</sup>lt;sup>1</sup> Method details in Table 3-2 are drawn from MT DEQ Analytical Requirements, Standards Methods (Rice et al., 2012), USGS protocols (NWQL, 2011), DPHHS Laboratory methods (DPHHS, 2015), and EPA laboratory methods (EPA, 2015).

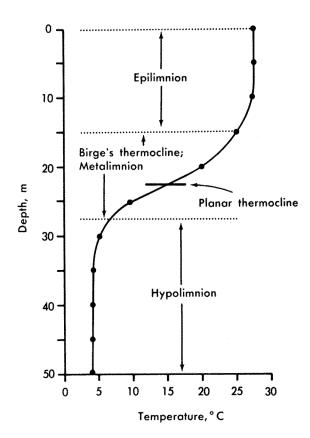


Figure 3-2. Typical temperature profile of a stratified lake, showing the epilimnion, thermocline (metalimnion), and hypolimnion; after Figure 9-2 in Cole (1983).

### 3.2.2 Sample Collection within each Identified Lake Water Layer

One or several HDPE carboys of sufficient volume (> 10 L) shall be used to composite multiple samples drawn from a single lake layer (e.g., epilimnion) or depth (e.g., 5 m). Prior to sampling a lake layer or a single depth, and also between the sampling of different layers and different depths, the HDPE carboy must be rinsed with 10% HCl solution, triple rinsed with DI water (twice with store DW, and once with laboratory DW), completely emptied, then rinsed with a small quantity of the lake sample-water prior to filing with the real sample water.

There will be 2 types of method collection for each layer (A, B below), the depth integrated and the single depth point.

### A. Depth Integrated Sample Method

Integrated water samples (**Table 3-2**) will be collected from each of the lake layers using a 5 L Hydro-Bios computer-controlled depth-integrating sampler (IWS III). Instructions for its use, including installation/operation of its software, are found in its operations manual (Hydro-Bios, 2015) which must be brought on board. Key points regarding the use of the Hydro-Bios Sampler:

 The start and end depth interval is programed prior to deployment via PC or Hand Unit. The start depth in the epilimnion should be 0.5 m.

- 2. There is a maximum velocity that the unit can be lowered through the water for depth integrated sampling (program will provide this velocity); estimate your lowering velocity in advance of deployment using a timing device and marks on the rope—do not exceed it during lowering. Uneven velocities during lowering (as long as they are below the velocity max) are adjusted for by the device; i.e., it will always collect a correctly integrated volume from each point during descent.
- 3. When the lower of the programmed depths is achieved, it will stop sampling and the device can be retrieved at any velocity.

A single IWS collection will be needed for samples taken using this method. Place the collected water into a single acid-washed carboy. Most of the samples collected by this method (see **Table 3-2**) are required to be kept in the dark. To minimize the light, the carboy must be covered with a tarp or canvas until you transfer the water to the proper container.

Samples will be collected from the epilimnion and metalimnion, at each site. Parameters to be collected at each layer are indicated on **Table 3-2**. The depth of integration should extend the entire thickness of each water layer (for the epilimnion, begin at 0.5 m). For the hypolimnion (taste and odor and cyanotoxins only - **Table 3-2**), collect an integrated water sample from the end of the metalimnion down to within 1 m of the bottom.

If the lake is not discernably stratified, collect a single depth-integrated sample, from the near-surface depth of 0.5 m down to within 1 m of the lake bottom.

### Phytoplankton Chlorophyll-a

**Avoid exposing samples to direct sunlight at all times.** Set up the filter apparatus prior to sample collection to minimize the time between sampling and filtration. Use clean forceps to place a glass fiber filter (GF/F nominal pore size 0.70 um) on the filter holder. Use a small amount of tap water from a wash bottle to help settle the filter properly. Rinse the sides of the filter funnel and the filter with a small volume of tap water. Attach the filter funnel and connect the plastic tubing and vacuum pump.

The carboy must be gently shaken before each sample extraction, to assure that particulate material in the lake water is uniformly suspended and not settled on the bottom.

Rinse a 500 ml graduated cylinder 3 times with a little correspondent water from the **water layer**. Measure 500 ml of lake water in the graduated cylinder, pour it into the filter funnel, and place the cap on the filter funnel. Draw the sample through the filter using the hand pump. To avoid rupture of fragile algal cells, do not exceed 9 inches Hg on the vacuum gage (Wetzel and Likens, 1991).

**Keep track of the volume of sample filtered!** The volume of sample filtered can vary. When filtration slows and the filter has developed a distinct green (or green-brown) color, sufficient sample has been filtered. Do not allow the filter to clog. If a filter completely clogs while water remains in the upper half of the filter funnel, discard the filter and start again, using less water volume.

After filtration is complete, unplug the hand pump, remove the filter funnel from the filter holder, and remove the filter with clean forceps. Avoid touching the colored portion of the filter. Fold the filter in half, with the colored side folded in on itself, and put the folded filter in a Petri dish. Add the label with a

clear tape. Place the foil-wrapped Petri dish in a small Ziploc bag. Immediately store the sample on dry ice; samples should be frozen upon delivery to the lab. The samples should be sent to the laboratory as soon as possible for analysis. See **Table 3-2** for where the samples will be sent to for laboratory analysis.

For the MT DEQ samples, fill out the Site Visit Form (SVF) according to the examples to be given by MT DEQ during the lake exercise session. See **Table 3-2** for who will receive the samples. For the other samples, follow the procedures under Attachment B.

### **Phytoplankton CNP**

The same procedure described below will be used for getting two samples. One filter will be used for CN and the other for P. Equal volume of water must be filtered on to each of these filters.

Set up the filter apparatus prior to sample collection to minimize the time between sampling and filtration. Use clean forceps to place a glass fiber filter (GF/F nominal pore size 0.70 um) on the filter holder. Use a small amount of tap water from a wash bottle to help settle the filter properly. Rinse the sides of the filter funnel and the filter with a small volume of tap water. Attach the filter funnel and connect the plastic tubing and vacuum pump.

The carboy must be gently shaken before each sample extraction, to assure that particulate material in the lake water is uniformly suspended and not settled on the bottom.

Rinse a 500 ml graduated cylinder 3 times with the correspondent **lake water layer**. Measure 500 ml of lake water in the graduated cylinder, pour it into the filter funnel, and place the cap on the filter funnel. Draw the sample through the filter using the hand pump. To avoid rupture of fragile algal cells, do not exceed 9 inches Hg on the vacuum gage (Wetzel and Likens, 1991).

**Keep track of the volume of sample filtered!** Volume of sample filtered can vary, but must be the same on each. When filtration slows and the filter has developed a distinct green (or green-brown) color, sufficient sample has been filtered. Do not allow the filter to clog. If a filter completely clogs while water remains in the upper half of the filter funnel, discard the filter and start again, using less water volume.

After filtration is complete, unplug the hand pump, remove the filter funnel from the filter holder, and remove the filter with clean forceps. Avoid touching the colored portion of the filter. <u>Do not fold the filter</u>. Put the unfolded filter in a Petri dish green side up.

Add the label with a clear tape. Place the Petri dish in a small Ziploc bag. Immediately store the sample on ice; samples should be kept on ice but not frozen until delivery to the Watershed Laboratory (**Table 3-2**). In the Watershed laboratory, CNP samples are to be kept in the refrigerator (not frozen) until final processing steps (provided below) are completed. Fill out the Site Visit Form (SVF) according to the examples to be given by MT DEQ during the lake exercise session.

At the MT DEQ Watershed Laboratory in Helena, one of the filters (for C & N analysis) will be placed on a filter holder and rinsed with 10% HCl until it stops fizzing, to remove inorganic carbonates (Nieuwenhuize et al., 1994). 50 ml of tap water will then be pulled through it to remove the acid, and then it will be dried at 105 °C. The remaining filter (for P analysis) will be dried directly. The first filter will be analyzed for C & N content using the high temperature induction furnace method (American Society of Agronomy, 1996), and the 2<sup>nd</sup> filter for total P content using methods outlined in Mulholland

and Rosemond (1992).

### **Phytoplankton ID and Density**

The carboy must be gently shaken before each sample extraction, to assure that particulate material in the lake water is uniformly suspended and not settled on the bottom.

Measure 1000 ml of the correspondent **lake water layer** in the graduated cylinder (no need to rinse the cylinder since it's the same one used for the CNP at the same layer), pour it into a dark 1000 Nalgene bottle. Preserve the sample by adding 0.5 ml alkaline Lugol's solution, follow immediately with adding 20 ml of buffered formalin and then 1 ml of 3% sodium thiosulfate to the dark bottle. Close the lid tightly and gently invert the bottle 3 times to distribute the preservative. Add the label with a clear tape. Immediately store the sample in a cooler without ice upon delivery to the lab. See **Table 3-2** for where the samples will be sent to for laboratory analysis.

For the MT DEQ samples, fill out the Site Visit Form (SVF) according to the examples to be given by MT DEQ during the lake exercise session. For the other samples, follow the procedures under Attachment B.

### **Phytoplankton Cyanotoxins**

The carboy must be gently shaken before each sample extraction, to assure that particulate material in the lake water is uniformly suspended and not settled on the bottom.

Rinse the bottle 3 times with the correspondent **lake water layer**. Pour it into a 60 ml amber bottle. Add the label with a clear tape. Immediately store the sample on ice for delivery to the lab. See **Table 3-2** for where the samples will be sent to for laboratory analysis.

For the MT DEQ samples, fill out the Site Visit Form (SVF) according to the examples to be given by MT DEQ during the lake exercise session. For the other samples, follow the procedures under Attachment B.

### **Taste and Odor Compounds**

The carboy must be gently shaken before each sample extraction, to assure that particulate material in the lake water is uniformly suspended and not settled on the bottom.

Pour sample water into <u>two</u> 40 ml bottles with zero head space (note: bottles will already contain sodium omadine preservative). Close the lid tightly and gently invert the bottle 3 times to distribute the preservative. Add the label with a clear tape. Immediately store the sample on ice for delivery to the lab. See **Table 3-2** for where the samples will be sent to for laboratory analysis.

For the MT DEQ samples, fill out the Site Visit Form (SVF) according to the examples to be given by MT DEQ during the lake exercise session. For the other samples, follow the procedures under **Attachment B**.

### **Zooplankton ID and Density**

Vertical tow with minimal drifting is necessary to get a good sample. A single tow sample will be collected from the bottom (hypolimnion) to the top (epilimnion) using an  $80~\mu m$  net. Minimal drifting is required. If not achievable, repeat the tow 2 more times. If that fails, make a note on the site visit

comment and do not collect the sample. The tow net, with a screened sample bucket attached at the bottom, is lowered to the desired depth, and raised at 0.5 meters per second to collect zooplankton from the water column. After lifting the net from the water, the net is sprayed using a bottle to wash the organisms down into the bucket. The sample is concentrated into the sample bucket. Organisms are transferred to a 500 ml bottle. Add 20 ml of soda water to narcotize the organisms. Let it stand for 30 minutes on ice, and then add ETOH to get a final concentration of 95% based on the sample volume collected. Close the lid tightly and gently invert the bottle 3 times to distribute the preservative. Add the label with a clear tape and parafilm to the lid cap. Immediately store the sample in a cooler without ice for delivery to the lab. See **Table 3-2** for where the samples will be sent to for laboratory analysis.

For the MT DEQ samples, fill out the Site Visit Form (SVF) according to the examples to be given by MT DEQ during the lake exercise session. For the other samples, follow the procedures under **Attachment B**.

### **B. Single Depth Point Sample Method**

Spot (grab) water samples from specified depths will be collected with the IWS III in SPOT mode, or if a failure occurs with the instrument, a Van Dorn bottle will be used instead (**Table 3-2**). For the IWS III, see instructions on page 23 of the manual. Lower to the depth of interest and keep it within  $\pm$  30 cm at that depth for 2 minutes while it fills. Retrieve the unit.

Sample should be collected near the center of the water layer, but adjusted to match the midpoint of a model layer (see Figure 3-3). Use 'Stratification & Secchi Form' to determine the start and end depths of layers. Two pulls of the 5 L integrator will be sufficient for all samples plus rinsing. If DO in the hypolimnion is ≤ 2 mg/L within 2 meters of the lake bottom, take an <u>additional</u> grab sample there within 2 meters of the lake bottom but again, per Figure 3-3, collected at the nearest 0.5 depth. Preserve it separately from the midpoint hypolimnion samples. If the lake is not discernably stratified, collect a single grab sample mid-depth, rounding to the nearest 0.5 m as needed.

In this method, because the IWS III holds 5 L, multiple collections within a water layer (e.g., epilimnion) will be needed. Repeat 1-3 as necessary; **no rinsing between sub-samples within the same lake layer is necessary**. Composite all draws from the same water layer into a single acid-washed carboy.

The IWS sampler and the Van Dorn should be rinsed twice with DI water (store grade) between sampling of different water layers and completely emptied of the DI water prior to sampling.

Two types of chemistry samples will be collected (filtered and non-filtered samples). Below is a description of how both types of samples will be collected.

<u>Unfiltered water samples</u>: Rinse the bottle 3 times with the correspondent lake water layer prior to collecting the final sample (see **Table 3-2** for the bottle size and preservative). Add the label with a clear tape. Immediately store the sample as described in **Table 3-2** for delivery to the lab. See **Table 3-2** for where the samples will be sent for laboratory analysis.

For the MT DEQ samples, fill out the Site Visit Form (SVF) according to the examples given by MT DEQ during the lake exercise session. For the other samples, follow the procedures under Attachment B.

Filtered water samples: Water will be filtered through a 0.45 μm filter using a 60cc syringe. Filtration will

be accomplished with a large syringe connected to a disposal filter capsule. A small amount of the sample will be wasted through the filter and the bottle will be triple-rinsed with the correspondent filtered **lake water** prior to collecting the final filtered sample (see **Table 3-2** for the bottle size and storage). Add the label with a clear tape. Immediately store the sample as described in **Table 3-2** for delivery to the lab. See **Table 3-2** for where the samples will be sent for laboratory analysis.

For the MT DEQ samples, fill out the Site Visit Form (SVF) according to the examples given by MT DEQ during the lake exercise session. For the other samples, follow the procedures under **Attachment B**.

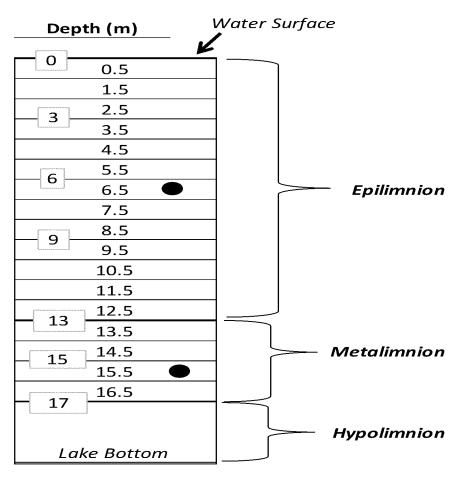


Figure 3-3. Example of where mid-layer water samples (black dots) are to be collected (only epilimnion, metalimnion shown). In this example, the epilimnion is 13 m deep, with a mid-point depth of 6.5 m. The epilimnion sample is collected at 6.5 m depth. The metalimnion is 4 m thick, with a midpoint depth of 15 m. In the metalimnion, round up to the next-nearest 0.5 meter depth (15.5 m in this case) and collect the sample there.

	ontainers, preservat	Lake Water					Analyzed by	
Parameters	Sampling Method	mpling Method Layer Bott		Container	Preservation and Storage	Holding Time	(Provide sample to)	
Temperature/conductivity, pH, DO, turbidity, chlorophyll a, and phycocyanin	YSI 6600 V2-4 sonde on cable	Every meter, surface to bottom	n/a	n/a	n/a	n/a	n/a	
PAR	Licor PAR meter on cable	Every meter, surface to bottom	n/a	n/a	n/a	n/a	n/a	
Secchi depth	30-cm diameter disc, shady side of boat	n/a	n/a	n/a	n/a	n/a	n/a	
Total phosphorus (TP), Total Nitrogen (TN)	3 point depths	n/a	250 ml		Freeze	45 days	MT DEQ	
Nitrate + Nitrite (NO <sub>2+3</sub> ), Total Ammonia (NH <sub>3+4)</sub> , Soluble Reactive Phosphorus (SRP)	3 point depths	n/a	250 ml		Field filter 0.45 um; Freeze	45 days	MT DEQ	
Total Suspended Solids (TSS)/ Total Dissolved Solids (TDS)/Volatile Suspended Solids (VSS)	3 point depths	n/a	1000 mi	HDPE bottles	Cool to <6°C (on ice)	7 days	MT DEQ	
Biochemical Oxygen Demand (BOD <sub>5</sub> )	3 point depths	n/a	1000 ml		Cool to <6°C (on ice)	48 hours	MT DEQ	
Carbonaceous Biochemical Oxygen Demand (CBOD <sub>5</sub> )	3 point depths	n/a	1000 mi		Cool to <6°C (on ice)	48 hours	MT DEQ	
Total alkalinity	3 point depths	n/a	n/a	n/a	n/a	In situ - field measurement	USGS/NWQL	
Total Organic Carbon (TOC)	3 point depths	n/a	125 ml	Amberglass	Preserve with H <sub>2</sub> SO <sub>4</sub> ; cool to <6oC (on ice)	28 days	USGS/NWQL	
Dissolved Organic Carbon (DOC)	3 point depths	n/a	125 ml	bottle	Field filter 0.45 um; preserve with $H_2SO_4$ ; cool to $<6^{\circ}C$ (on ice)	28 days	USGS/NWQL	
Silica, sulfate and chloride	3 point depths	n/a	250 ml		Cool to <6°C (on ice)	USGS-field measurement; MT DEQ- 14 days for TA; 28 days for sulfate, chloride and silica	USGS/NWQL	
Total recoverable iron( Fe), arsenic (As), manganese (Mn)	3 point depths	n/a	250 ml	HDPE bottle	Preserve with HNO <sub>3</sub> ; cool to <6°C (on ice)	180 Days	USGS/NWQL	
Dissolved Fe , As , Mn	3 point depths	n/a	250 ml	nbre bottle	Field filter 0.45 um; preserve with HNO <sub>3</sub> ; cool to <6°C (on ice)	180 days	USGS/NWQL	
Dissolved Silica	3 point depths	n/a	250 ml		Field filter 0.45 um; cool to <6°C (on ice)	28 days	USGS/NWQL	
Total Sulfide	3 point depths	n/a	n/a	n/a	n/a	In situ - field measurement	USGS/NWQL	
Dissolved Sulfide	3 point depths	n/a	n/a	n/a	n/a	In situ - field measurement	USGS/NWQL	
Phytoplankton chlorophyll a & Ash Free Dry Weight	I depth integrated	E, M (INT)	1000 ml	Petri dish (filter)	Freeze	180 days	MT DEQ	
Phytoplankton CNP	depth integrated	E, M (INT)	1000 mi	Petri dish (filter)	Cool to <6°C (on ice)	n/a	MT DEQ	
Taste & odor compounds (geosmin, 2-methylisoborneol, and 2,4,6-Trichoroanisole)	depth integrated	E, M, H (INT)	40 ml -two bottles per water layer	Glass VOA bottles, septum caps (zero head space)	Sodium omadine; Cool to <6°C (on ice)	14 days	MT DEQ	
Cyanotoxins (microcystin only at this time; others ?)	depth integrated	E, M, H (INT)	60 ml	amber glass, half filled	Freeze. Samples will be shipped with blue ice.	30 days	MT DEQ	
Phytoplankton (mg/L) and ID	depth integrated	E, M, H (INT)	1000 ml	Dark HPDE bottle	Alkaline Lugol's - Formalin-Sodium Thiosulfate -cooler w/o ice	n/a	MT DEQ	
Zooplankton (mg/L) and ID	1 vertical net tow, 80 μm Wisconsin net, bottom to surface	n/a	500 ml	HDPE bottles	95% ETOH - cooler w/o ice	n/a	MT DEQ	
Sediment Cores	Water at 2 m; core at the bottom	Н	n/a	Plastic cores	Ambient lake bottom temperature on ice chest	14 hours	MT DEQ	

<sup>&</sup>lt;sup>1</sup> E - epilimnion; M - metalimnion; H - hypolimnion. Point means a grab sample at the midpoint of each layer; INT means depth integrated for the full extend of a layer.

## 3.2.4 Protocol for Deriving Sonde Depth when Boat Drift is Substantial and Sonde is Not Equipped with a Depth Sensor

In this situation the true depth of the sonde will be difficult to know and will have to be back-calculated. Determine the cable's angle relative to the water surface and determine the true instrument depth using **Figure 3-4** and the following equations:

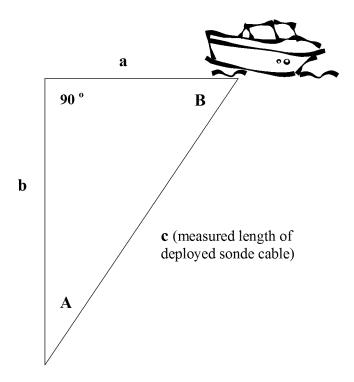


Figure 3-4. Trigonometric values used to determine depth of YSI sonde if the sonde cable forms an angle relative to the water surface.

Step 1: Estimate angle **B** (water surface relative to cable angle). A large woodworker's T-bevel or similar device, along with a protractor, can be used for this purpose. Step 2: Determine angle **A** as:  $\mathbf{A} = 180 - [90 + \mathbf{B}]$ . Step 3: **b** (actual depth of sonde) = **c** cos **A**. An Excel spreadsheet is used to rapidly determine the true depth of each data collection point.

## 3.2.5 Lake-bottom Sediment Oxygen Demand (SOD)

### In the Field:

MT DEQ will carry out laboratory-based core incubations in Helena, but core samples and water will be collected at Canyon Ferry by USGS. The MT DEQ SOD Form, one form per site, will be used to record supplementary data not included on the regular site-visit form. Previous researchers began their SOD measurements from 6 hours to "overnight" (about 14 hours) after collection (Edwards and Rolley, 1965; Truax et al., 1995). We will also commence SOD measurement within 14 hours of collection.

<u>Duplicate</u> core samples will be taken from two Canyon Ferry sampling sites (Site 2 and 3; **Figure 3-1**). A

ball-check gravity core sampler will be used to remove the sediment from the site and samples will be stored in plastic core liner tubes prior to analysis. The sampler will be handled as carefully as possible to remove and transport the sediment core from the field to the laboratory (e.g. the reaction chamber) with the least possible disturbance.

Water for the water-only test will be collected at a depth close (within a meter of the bottom) to where the sediment will be removed, and prior to removal to the sediment core, using a Van Dorn sampler. Record the near-bottom water temperature with YSI sonde. The person doing the sampling should be careful not to disturb any of the underlying sediment when collecting the water sample. After collection, both water and sediment will be stored in a dark ice chest with water held within  $\pm$  5 ° C of the lake bottom's temperature prior to and during the analyses in the MT DEQ watershed laboratory.

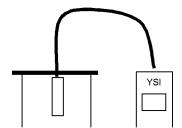
### In the MT DEQ Watershed Laboratory:

Per EPA (Mills et al., 1986), in situ measurements of SOD are preferable to laboratory sediment-cores techniques. However, due to difficulty with reservoir logistics (e.g., water depth), the laboratory batch reactors described by Edburg and Hofsten (1973) and Bowman and Delfino (1980) will be used. In situ methods commonly provide higher SOD values than their laboratory equivalents (Bowman and Delfino, 1980), however good agreement between in situ and laboratory methods (within 10%) are also reported (Pamatmat, 1971; Bowman and Delfino, 1980). Measured SOD can range over three orders of magnitude (Edburg and Hofsten, 1973; Bowman and Delfino, 1980), therefore assigning an SOD to Canyon Ferry Lake from the literature would likely be incorrect; for this reason we will measure SOD directly.

Laboratory-based SOD measurement is based on the observed differences in the oxygen concentration of two sealed chambers. One chamber contains only lake water which provides information on the water column oxygen demand. The second sealed container includes both water and the sediment core which has been extracted from the lake. Changes in the DO concentration of the chamber over time define the SOD. The SOD (g  $O_2$  m<sup>-2</sup> day<sup>-1</sup>) can be calculated, per Drolc and Koncan (1999), as:

$$SOD = \frac{aV - bV}{S} \tag{1}$$

where a is the slope of the time-DO curve for the combined sediment and water in a chamber (g O<sub>2</sub> m<sup>-3</sup> day<sup>-1</sup>), b is the slope of the time-DO curve for the water of the chamber not interfaced with the sediments (g O<sub>2</sub> m<sup>-3</sup> day<sup>-1</sup>), V is the volume of overlaying water in the chamber interfaced with the sediments (m<sup>3</sup>), and S is the area of the chamber (m<sup>2</sup>). A chamber similar to the approach presented in Bowman and Delfino (1980) will be used for the analysis (**Figure 3-5**) and has been used by MT DEQ before (Kusnierz, 2009). The incubations will be carried out in a dark water bath kept as close to the lakes bottom-water temperature as is feasible and within  $\pm$  5 ° C of it. Incubations will last several hours or up to two days, depending on the observed DO decline. The MT DEQ SOD Form will be used to record the incubations. Reproducibility of paired duplicates should be good, i.e. with  $\pm$  20%, per Bowman and Delfino (1980).





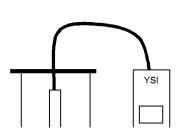




Figure 3-5. General diagram of the SOD batch reactor chamber proposed for use in the project. The final design will be similar to this basic layout.

### 3.3 RIVER INFLOW AND OUTFLOW SAMPLING

Water-quality sampling will be conducted at two sites as described in **Section 3.1**. Standard USGS methods for equal depth- and width-integrated (EWI) sampling (**Figure 3-6**) will be implemented at Missouri River at Hwy 287 bridge site as described in the USGS National Field Manual (USGS, variously dated). Sample collection at Missouri River below Canyon Ferry dam will be from a single vertical grab located near mid-channel. At both sites, water samples will be composited in an acid-washed HDPE carboy (see **Section 3.2.2** above for cleaning protocol of the carboy). Sample processing will be conducted as described in **Table 3-3**.

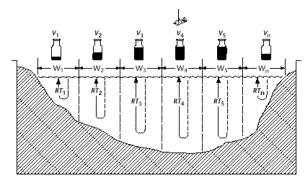


Figure 3-6. Equal Width Increment (EWI) Schematic, used at the Missouri River Hwy 287 Bridge site.

Samples collected at Missouri River at the Hwy 287 Bridge and at Missouri River below Canyon Ferry Dam will be analyzed for all parameters listed in **Table 3-3**. Note that some samples will be analyzed by USGS's NWQL in Denver, CO, whereas other samples will be collected by USGS and provided to MT DEQ who will then provide them to a laboratory of their choice **(Table 3-3)**.

Two types of chemistry samples will be collected (filtered and non-filtered samples). Below is a description of how both types of samples will be collected.

<u>Unfiltered water samples</u>: Rinse the bottle 3 times with the correspondent **river water** prior to collecting the final sample (see **Table 3-3** for the bottle size and preservative). Add the label with a clear tape. Immediately store the sample as described in **Table 3-3** for delivery to the lab. See **Table 3-3** for where the samples will be sent to for laboratory analysis.

For the MT DEQ samples, fill out the Site Visit Form (SVF) according to the examples given by MT DEQ during the lake exercise session. For the other samples, follow the procedures under Attachment B.

<u>Filtered water samples:</u> Water will be filtered through a 0.45 µm filter using a 60cc syringe. A small amount of the sample will be wasted through the filter and the bottle will be triple-rinsed with the filtered river water prior to collecting the final filtered sample (see **Table 3-3** for the bottle size and storage). Add the label with clear tape. Immediately store the sample as described in **Table 3-3** for delivery to the lab. See **Table 3-3** for where the samples will be sent for laboratory analysis.

For the MT DEQ samples, fill out the Site Visit Form (SVF) according to the examples given by MT DEQ during the lake exercise session. For the other samples, follow the procedures under Attachment B.

Table 3-3. Sample types, methods, locations, containers, preservation, holding times, and sample recipients for the river sampling sites (I) and (O).

					,	Analyze	d by (provide sample to)		
Missouri River Inflow (I) and/or Outflow (O)	Sampling Method	Bottle Size	Container	Preservation and Storage	Holding Time	Missouri R. at Hwy Bridge (I)	Missouri R. below dam (O)		
Chloride (I and O)	EWI (I); grab (O)	250 ml	HDPE bottle	Field filter 0.45 um	180 days	USGS/NWQL	USGS/NWQL		
Dissolved Organic Carbon (DOC) -I and O	EWI (I); grab (O)	125 ml	Baked amber glass bottle	Field filter 0.45 um; acidify with 1 ml 4.5N H2SO4; cool to <4°C (on ice)	28 days	USGS/NWQL	USGS/NWQL		
Total Organic Carbon (TOC) - (I) already under JFA and (O)	EWI (I); grab (O)	125 ml	Baked amber glass bottle	Cool to <4°C (on ice)	14 days	USGS/NWQL	USGS/NWQL		
Total recoverable arsenic (As) and silica (Si)	EWI (I); grab (O)	250 ml	HDPE bottle	Acidify with 2 ml 7.5N Ultrex HNO3	180 days	USGS/NWQL	USGS/NWQL		
Dissolved arsenic (As) and Silica (Si)	EWI (I); grab (O)	250 ml	HDPE bottle	Filed filter 0.45 um; acidify with 2 ml 7.5N Ultrex HNO3	180 days	USGS/NWQL	USGS/NWQL		
Total Phosphorus (TP), Total Persulfate Nitrogen (TN) - (I) already under JFA	FWH III	125 ml	HDPE bottle	Acidify with 1 ml 4.5N H2SO4; cool to <4°C 30 days (on ice)		USGS/NWQL	MT DEQ		
Nitrate + Nitrite (NO2+3), Total Ammonia (NH3+4), Soluble Reactive Phosphorus ( SRP) - ( <i>I</i> ) already under JFA	EWI (I)	125 ml	Brown HPPE bottle	Field filter 0.45 um; cool to <4°C (on ice)	30 days	USGS/NWQL	MT DEQ		
Total Phosphorus (TP), Total Persulfate Nitrogen (TN) - (O)	1 0100101 1	250 ml		Freeze	45 days	USGS/NWQL	MT DEQ		
Nitrate + Nitrite (NO2+3), Total Ammonia (NH3+4), Soluble Reactive Phosphorus ( SRP) - (O)	Grah   O	250 ml		Field filter 0.45 um; Freeze	45 days	USGS/NWQL	MT DEQ		
Total Suspended Solids (TSS)/ Total Dissolved Solids (TDS)/Volatile Suspended Solids (VSS) - (I and O)	EWI (I); grab (O)	1000 ml	HPDE bottle	Cool to <6°C (on ice)	7 days	NWQL/MT DEQ	MT DEQ		
Biochemical Oxygen Demand (BOD) - (I and O)	EWI (I); grab (O)	1000 ml		Cool to <6°C (on ice)	48 hours	MT DEQ	MT DEQ		
Carbonaceous Biochemical Oxygen Demand (CBOD) - (I and O)	EWI (I); grab (O)	1000 ml		Cool to <6°C (on ice)	48 hours	MT DEQ	MT DEQ		
Phytoplankton chlorophyll a & Ash Free Dry Weight - (I and O)	EWI (I); grab (O)	1000 ml	Petri dish (filter)	Freeze	180 days	MT DEQ	MT DEQ.		
Phytoplankton CNP - (I and O)	EWI (I); grab (O)	1000 ml	Petri dish (filter)	Cool to <6°C (on ice)	NA	MT DEQ	MT DEQ		

## 3.4 INSTRUMENTS (LAKE AND RIVERINE SITES)

For the lake sites, real-time measurement of parameters (DO, pH, chlorophyll a, phycocyanins, conductivity, temperature, turbidity and pH) will be undertaken using a YSI 6600 V2-4 sonde. Calibration

will be completed according to the manufacturer's instructions (see **Section 6.1** for calibration methods) prior to each monthly sampling event. Photosynthetically Active Radiation (PAR) will be measured with a Li-COR meter according to the requirements in **Attachment B**. Five miniDots (DO/temperature loggers) were vertically deployed—equipped with coarse Cu screens for antifouling—at a single site at Canyon Ferry Lake as described in the Canyon Ferry Pilot Project SAP (Sada, 2015).

For the riverine sites, physical parameters of water-temperature, specific conductance, pH, dissolved oxygen, and alkalinity will be determined during the time of sample collection as described on **Attachment B**.

Instantaneous discharge will be determined at the Missouri River at Hwy 287 Bridge near the time of sampling using either current meters or an Acoustic Doppler Current Profiler (ADCP) according to the procedures described in **Attachment B**. Discharge values for Missouri River below Canyon Ferry dam will be obtained from the Bureau of Reclamation dam release data.

Two miniDOTs (DO/temperature loggers) will be deployed in May—equipped with coarse Cu screens for antifouling—one at the Missouri River inlet site, one at the outlet site. The MiniDOT logger does not require any pre-calibration. Instructions on how to turn on the instrument before deployment, and turn it off after retrieval can be found in the miniDOT Logger User's Manual (Precision Measurement Engineering, 2014).

## 3.5 SHORELINE/BEACH AREAS: CYANOTOXIN AND TASTE & ODOR SAMPLING

Shoreline samples for (A) cyanotoxins and (B) taste & odor compounds will be collected at five popular recreation areas (Figure 3.1). Sampling will occur monthly and be coordinated to occur the same week as the in-lake sampling in Section 3.2. Samples will be collected by wading from the water's edge to a depth of 0.5 m and collecting a grab sample just under the surface (Graham et al., 2008). This will involve one 60 ml bottle for cyanotoxins and two 40-ml bottles for taste & odor compounds as described in Section 3.2.2. Add the label with a clear tape. Immediately store the sample as described in Table 3-2 for delivery to the lab. See Table 3-2 for where the samples will be sent to for laboratory analysis. If a visible scum-like layer of cyanobacteria are present, wear gloves, and collect and preserve a phytoplankton ID sample for later analysis per Table 3-2.

For the MT DEQ samples, fill out the Site Visit Form (SVF) according to the examples given by MT DEQ during the lake exercise session. For the other samples, follow the procedures under **Attachment B**.

## 3.6 PHYSICAL AND HABITAT PARAMETERS

## 3.6.1 Digital Photographs

Digital photographs will be taken at each site (riverine, lake and shoreline) every time to document the

basis character of each site with respect to the phytoplankton succession. The photo number and pertinent site information will be recorded for each photo.

## 3.6.2 Meteorological Measurements

Two independent weather stations were deployed by MT DEQ at two sites in April 2015 as described in the Canyon Ferry lake Pilot Project (Sada, 2015).

## 4.0 Sample Handling Procedures

To minimize site disturbance which may bias samples, at each site we will collect parameters that are most sensitive to disturbance before monitoring parameters that are less sensitive to disturbance. The general sequence is as follows:

- 1. Chemistry parameters (e.g., in situ field measurements, water chemistry, phytoplankton Chla)
- 2. Biological parameters (zooplankton tows)
- 3. Physical/other parameters (e.g., SOD cores, photographs)

This project follows the WQPB "internal process." Appropriate storage times for samples are presented in **Tables 3-2** and **3-3** above. Samples indicated as 'MT DEQ' in the tables will be delivered to the DPHHS Laboratory in Helena, MT, whereas those marked as 'USGS/NWQL' will be provided to the NWQL in Denver, CO. Phytoplankton ID samples will be sent to the Philadelphia Academy of Natural Sciences in Philadelphia, PA, zooplankton ID samples will be sent to Rhithron Associates, Inc. in Missoula, MT. Phytoplankton CNP samples will be sent to the Penn State University Agricultural Analytical Services Laboratory.

## 5.0 Laboratory Analytical Methods

Please see Table 10.1 in the project QAPP.

## 6.0 Quality Assurance and Quality Control Requirements

All QA/QC requirements followed by MT DEQ "internal process" will be instituted for this project. The QA/QC requirements are described MT DEQ's field monitoring QAPP (Montana Department of Environmental Quality, 2005). Sample replicates will be randomly taken on at least 10% of the total samples for each parameter. Exceptions exists (phytoplankton ID and zooplankton ID will not have replicates collected in the field). Water sample field blanks will be made prior to departure from the field at the end of each sampling run ("trip"). For parameters to be analyzed by the USGS, the duplicate and field blank requirements are indicated in **Attachment B**. All continuous data logger records (e.g., from MiniDOTs) will be reviewed *a posteriori* using methods detailed in the Yellowstone River model QAPP addendum (Suplee, 2007). Using those methods, logged data will be appropriately flagged prior to the data records being submitted for storage in MT EquiS.

### 6.1 YSI 6600 V2-4 CALIBRATION

Prior to each monthly sampling event, sonde calibration will be completed by MT DEQ or USGS in accordance with the manufacturer's instructions/guidance (YSI Incorporated, 2010). NIST traceable standards will be used. Relevant pages numbers in YSI (2010) are provided below. Calibrate as close to 20  $^{\circ}$  C as possible, record all calibration data on the MT DEQ YSI Pre-deployment Calibration Form.

**pH**: Two-point calibration (standard buffers 7.0 and 10.0). Make sure that the millivolt output of the pH is turned on and that the probe's values are within the specified ranges (page 2). **DO**: One-point saturated air method (page 6).

**Specific Conductivity**: Single point using a 1000  $\mu$ S/cm standard (page 1).

Turbidity: Two-point using zero NTU and 123 NTU standard solutions (page 8).

**Chlorophyll a:** One-point using DI water, setting the input to zero (page 14). Then check and record the chlorophyll a reading against a solution made as follows. 1) Transfer 5.0 ml of Rhodamine WT<sup>2</sup> via volumetric pipette into a 1000 ml volumetric flask and fill to flask line with DI water, mix. This solution is referred to as the "stock solution". Keep in a dark amber bottle refrigerated. 2) On the day of calibration, take a small volume of stock solution and warm to room temperature, then transfer 1.0 ml of it via volumetric pipette to a 1000 ml volumetric flask and fill to line with DI water, mix. This new, light-pink solution will usually read about 21-24  $\mu$ g/L on a just-zeroed chlorophyll probe.

**Phycocyanin:** Follow the same zeroing and benchmarking methods described for chlorophyll a.

## 7.0 Data Analysis, Record Keeping, and Reporting Requirements

This project will follow the WQPB "internal process." Site Visit/Chain of Custody forms, field forms, digital photos, and laboratory results will be processed by WQPB staff following QA/QC procedures as indicated in **Section 6.0**. Data collected under this SP will be housed in MT DEQ's surface water database MT-eWQX (http://deq.mt.gov/wqinfo/datamgmt/MTEWQX.mcpx) and incorporated into a technical report after the completion of the 2 year field-collection work. The technical report will describe the calibrated and validated CE-QUAL-W2 model for Canyon Ferry Lake and the nutrient criteria derived thereof. Based on previous nutrient-criteria modeling work (Flynn and Suplee, 2013), the final report may take several years to complete (~2019).

## 8.0 Schedule

Lake sampling including shoreline sites will typically occur the third week of each month according to **Table 8-1** below. At the river sites, sampling (which usually occurs twice monthly) will occur (A) early in the month and then (B) in alignment with the lake sampling week.

<sup>&</sup>lt;sup>2</sup> Fluorescent FWT Red Dye (Lot# 257201; 16 fl. Oz.), Kingscote Chemicals, 9676 N. Looney Road, Piqua, OH 45356, or equivalent.

Table 8-1. Sampling schedule for Canyon Ferry Lake and Missouri River sites 2015 through 2016.

				201	5		2016										
Sites	A	M	J	J	A	S	0	N	D through M	Α	M	J	J	А	S	0	N
Canyon Ferry Lake sites (3 sites, each site will be sampled at 3 depths)	-	1	1	1	1	1	1	1	-	1	1	1	1	1	1	1	1
Missouri River at the Hwy 287 bridge at Townsend	1*	2	2	2	2	1	1	1	-	1	2	2	2	2	2	1	1
Missouri River below Canyon Ferry Dam	1*	2	2	2	2	1	1	1	-	1	2	2	2	2	2	1	1
Shoreline sites (5)	-	1	1	1	1	1	1	1	-	1	1	1	1	1	1	1	1

<sup>\*</sup> This month only under JFA placed in 2014

## 9.0 Project Team and Responsibilities

Please see the organization chart, **Figure 1-1** of the Project QAPP. Rosie Sada and Michael Suplee are coleads for the organization and field components of this project, with the majority of the work being completed by MT DEQ's cooperative partner USGS. Kyle Flynn is lead on the modeling aspects of the project. Subcontractors were detailed in **Section 4.0**.

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